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Impact of instructional leadership on high school student academic achievement in China

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Abstract
The purpose of this study was to examine the impact of instructional leadership on high school students' academic achievement in the Chinese context and to determine which specific instructional leadership dimensions have the most important role. The sample included 26 high schools with 26 principals and 4288 students in Shenyang, China. The principals rated their instructional leadership according to the Revised Instructional Leadership Questionnaire of China (ILQC-R). The hypotheses were tested using hierarchical linear models. The results indicated that, after controlling for student background, school context, and principal demographics, overall instructional leadership showed a significantly moderating influence on the relationship between high school entrance scores and college entrance scores for students. Regarding the four different dimensions, different influence trends were observed. The dimensions of managing instruction, defining the school mission and goals, and promoting teacher development were found to influence students' college entrance scores in both direct and indirect ways; however, no significant impact on students from managing public relations was found.

Keywords Instructional leadership · High schools · Student academic achievement · Hierarchical linear model

Introduction

As school leaders, principals are regarded as the key to implementing effective policies and achieving external accountability objectives (Hallinger and Walker 2017; Walker and Qian 2018). Therefore, school principals' leadership has received considerable international interest because it is an influential variable in understanding school effectiveness (Hallinger et al. 2013; Zheng et al. 2017; Lai et al. 2017). The main issue that drives scholars to address this question is that the goal of reducing the persistent disparities among different schools can be achieved by changing school principals (Robinson et al. 2008). By providing more systematic training for principals, their leadership can be strengthened so that the overall quality of school education can be improved (Tang et al. 2014).

Since the early 1980s, research on principals' leadership has shifted from focusing on general leadership to investigating different types of specific leadership (Pan et al. 2015; Lai et al. 2017). Instructional leadership refers to the principal's direct engagement with teaching and learning processes (Hallinger and Murphy 1985), transformational and transactional leadership emphasises the leader's role in inspiring others to achieve a collective vision of change and in motivating members to develop their capabilities (Leithwood and Jantzi 2000), teacher leadership refers to educators other than principals being responsible for student learning (Lambert 2002), and collaborative leadership refers to leadership that includes school administrators, teachers, parents, and others in improving the organisational attributes of schools (Hallinger and Heck 2010). With the rise of worldwide educational reform, enhanced recognition of school effectiveness, and standard-based accountability systems in the twenty-first century, principals' instructional leadership has

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received increasing attention (Pan et al. 2015; Zhao 2018) and has been considered the most important of all leadership theories (Hallinger et al. 2015; Zheng et al. 2017). Despite the diversity of definitions across different studies (Hallinger 2003; Robinson et al. 2008; Qian et al. 2017), principals' instructional leadership is generally defined as the leadership functions that support classroom teaching and student learning (Murphy 1988; Anderson 2008; Hallinger and Murphy 2012).

There is long-standing interest in the question of whether instructional leadership influences school effectiveness, which is usually evaluated by student academic achievement (Robinson et al. 2008; Supovitz et al. 2010). Historically, both qualitative and quantitative empirical studies have been conducted worldwide with the aim of addressing this question (Witziers et al. 2003; Leithwood and Mascall 2008; Sammons et al. 2011). Previous studies demonstrate that instructional leadership has the strongest empirical impact on student learning outcomes among all types of leadership (Hallinger et al. 2015). For example, Robinson and her colleagues conducted a meta-analysis and found that the average impact of instructional leadership on student learning outcomes was 3 to 4 times that of transformational leadership (Robinson et al. 2008). However, a literature review discovered an important knowledge gap in findings on the effectiveness of instructional leadership. First, most existing studies focus on elementary schools (Alig-Mielcarek and Hoy 2005; Shatzer et al. 2014; Day et al. 2016), while only a few studies focus on high schools (Heck et al. 1990, 1991; Brewer 1993). Moreover, some people argue that high school principals have important roles (Wang 2016). Second, a considerable number of studies have indicated that the effect sizes of instructional leadership may vary among different cultural backgrounds (Robinson et al. 2008; Qian et al. 2017; Zhao 2018). The average effect sizes are found to be stronger in America than in other countries (Robinson et al. 2008). As some researchers have noted, cultural differences lead to different roles of principals and different ways that leadership is perceived by principals (Zhao 2018). Third, empirical evidence on instructional leadership is still very limited in China, although the emphasis in this field has been gradually increasing (Walker and Qian 2018). Except for some reviews (for example, Pan et al. 2015; Qian et al. 2017), few studies have been conducted to explore the relationship between instructional leadership and student academic achievement in the Chinese context. Finally, most previous quantitative studies used cross-sectional data to explore the relationship between instructional leadership and student academic achievement (Hallinger et al. 1996; Alig-Mielcarek and Hoy 2005; Shatzer et al. 2014).

The overall objective of this research is to explore the impact of principals' instructional leadership on high school students' academic performance in a Chinese context using hierarchical linear modelling (HLM). To investigate the influence of instructional leadership in the improvement of students' academic performance over 3 years, students' high school entrance scores at the preliminary stage in high school and their college entrance scores at the end of high school were both used. The variable of the high school entrance score was employed as a predicting variable. There are three specific purposes of this study:

(1) To examine whether instructional leadership significantly predicts high school students' academic achievement after controlling for student demographic information, school context, and principal demographics.
(2) To compare the effects of instructional leadership on liberal arts and science students' achievement.
(3) To investigate the effect of each instructional leadership dimension on liberal arts or science students' achievement.

Literature review

Definition of principals' instructional leadership

Principals' instructional leadership has historically been considered a personal characteristic (MacNeill et al. 2003, 2005; Hallinger et al. 2015). Currently, it is widely accepted that instructional leadership comprises behaviour, action, and practice (Mulford 2008). The core role of principals as instructional leaders is to provide support for instruction, including supervising and evaluating teachers' teaching, properly planning teacher professional development courses (King 2002), and managing teaching strategies (King 2002; Anderson 2008; Hallinger and Murphy 2012). Robinson et al. (2008) suggested a five-dimensional framework for instructional leadership: (1) establishing goals and expectations; (2) strategic resourcing; (3) planning, coordinating, and evaluating teaching and the curriculum; (4) promoting and participating in teacher learning and development; and (5) ensuring an orderly and supportive environment. Hallinger and Murphy (1985) and Hallinger et al. (2015) proposed a widely used conceptual framework called the PIMRS (principal instructional management rating scale) with three dimensions: defining the school mission, managing the instructional programme, and developing a positive school learning climate.

Principals with high-level instructional leadership tend to direct their attention towards the academic aspects of their schools, such as setting academic goals, developing curricula, assessing the effectiveness of teachers' instructional practices, and providing opportunities for instructional improvement (Southworth 2002; Marks and Printy 2003; Hallinger 2003, 2011). Principals with low-level

instructional leadership are generally "narrow", for example, focusing only on actions or activities directly related to teaching and ignoring the value of administrative activities (Murphy 1988). This narrow understanding of instructional leadership may lead to confusion about the role of principals (Zhao 2018) and may even lead to the conclusion that the role does not have a significant impact on student performance (Wiseman and Goesling 2000; Zheng et al. 2017).

Conceptualisation of instructional leadership in the Chinese context

The conceptualisation of principals' instructional leadership may also vary by cultural context (Anderson 2008; Wang 2016; Qian et al. 2017). For example, findings based on five societies in East Asia (China, Malaysia, Taiwan, Vietnam, and Singapore) indicated that there are differences in terms of how this construct is defined and how principals manage or influence teaching and learning (Hallinger and Walker 2017).

In China, with the expansion of educational reform, the influences of Western culture on leadership, and the increasing demands of professional development, the roles of principals have changed dramatically (Zhao and Qiu 2012; Qian et al. 2017). Therefore, the question has been raised of how to define instructional leadership in the Chinese context. Some Chinese scholars define instructional leadership based on its responsibilities and activities (Li and Zhang 2006). Most Chinese scholars tend to define instructional leadership as principals' capability to influence teachers, students, and other stakeholders and to coordinate the curriculum and teaching (Zhao and Liu 2010; Zhao 2010, 2013). Based on previous scholars' work (Zhao 2010; Chu and Liu 2010; Yang and Wen 2009), a conceptual model of instructional leadership with four interrelated dimensions was constructed by Zhao and Liu (2010). These four dimensions included (a) defining the school mission and goals, (b) promoting teacher development, (c) managing instruction, and (d) managing public relations. Building on this definition, Zhao and Liu (2010) developed the *Instructional Leadership Questionnaire of China* (ILQC) with 85 items. A total of 138 Chinese education officials, principals, and school administrators were interviewed with the aim of investigating whether the items appropriately depict the attributes of instructional leadership in the Chinese context. Subsequently, Zhao and Liu (2010) customised the ILQC into a short version, the ILQC-R (50 items). It has been demonstrated that both versions have good reliability and validity (Zhao 2018).

A close examination of the differences between the PIMRS and ILQC-R revealed that Chinese principals focus more on teaching-based research activities in schools, which is well recognised as one of the most important approaches for improving teaching quality (Zhao 2018). This result explains why "promoting teacher development" was identified as an independent dimension in the ILQC. In addition, given the top-down educational system (Tang et al. 2014), Chinese principals are also accountable to the government for school improvement. Therefore, in addition to developing a positive school climate, principals need to address the relationship with the local education department. Interpersonal relationships among teachers is another issue that has received increasing attention from Chinese principals (Walker and Qian 2018).

Relationship between principals' instructional leadership and students' academic achievement

Strong instructional leadership has been widely recognised as the core factor in school development and plays a substantial role in improving school effectiveness (Allen et al. 2015) and quality (Hallinger 1992; Hallinger et al. 2015). Given that numerous studies have been conducted, an increasing number of researchers have employed meta-analysis methods to discover the trends of such relationships (Marzano et al. 2005; Robinson et al. 2008; Hallinger and Bryant 2013) (see Table 1). Although the positive influence of instructional leadership on students' academic performance has been confirmed and recognised in different countries (Hallinger 1992; Hallinger et al. 2015), the effect size of this relationship varies greatly (Marzano et al. 2005; Robinson et al. 2008; Pan et al. 2015).

Direct and indirect relationships

In earlier reviews, instructional leadership was combined with other types of leadership (Hallinger and Heck 1998; Witziers et al. 2003; Marzano et al. 2005), and the conclusions were mixed. Hallinger and Heck (1998) and Witziers et al. (2003) noted that the direct impact of principals' leadership on student academic achievement was relatively small and was essentially mediated by teachers. In contrast, Marzano et al. (2005) revealed the opposite conclusion by reporting a substantial relationship with a mean effect of approximately 0.4.

In contrast to these reviews, other researchers tend to focus on instructional leadership rather than principals' overall leadership (Hallinger 2005; Robinson et al. 2008; Pan et al. 2015). In these reviews, the indirect relationship of instructional leadership has been confirmed (Hallinger et al. 1996; Bruggencate et al. 2012; Zheng et al. 2017). These authors believe that instructional leadership influences students' academic achievement by establishing a strong instructional atmosphere and improving teachers' motivations. For example, Bruggencate et al. (2012) employed a structured model SEM using data from 97 secondary schools in the Netherlands and found that there

Table 1 Reviews on the effects of instructional leadership on student academic achievement

Year	Author	# of studies	Nation or region	Time	Types of leadership	Type of effect	Effect size
1998	Hallinger and Heck	43	United States, Canada, Singapore, England, Netherlands, Marshall Islands, Israel, & Hong Kong	1980–1995	Overall leadership	(1) Direct effects (2) Mediated effects (3) Reciprocal effects	Direct: effect size = 0.09 Indirect model mediated by teachers: χ^2/df = 1.3, p = 0.064; TLI = 0.90; RMSEA = 0.80
2003	Witziers et al.	37	25 countries	1986–1996	Overall leadership	Direct effect	Mean effect size = 0.02
2005	Marzano et al.	70	United States	1970–2000	Overall leadership	Direct effect and indirect effect	Mean effect size = 0.4
2005	Hallinger	116	North America, Europe, and Asia	1983–2005	Instructional leadership	Direct effect	The effect size is quite small although statistically significant
2008	Robinson et al.	27	United States, Canada, Australia, England, Hong Kong, Israel, Netherlands, New Zealand, and Singapore	1978–2006	Transformational and instructional leadership	Direct effect	The mean effect size for instructional leadership on students' academic achievement is 0.42, for transformational leadership is 0.11, & for other types of leadership is 0.32
2015	Pan et al.	80	Chinese Taiwan	1994–2012	Instructional leadership	Direct effect and indirect effect	Stronger indirect than direct leadership behaviours

was no significant direct effect of principals' leadership on the mean promotion rate in schools; however, school leaders' behaviour could have an indirect effect on student achievement through a series of actions that shape the school context.

Variations of the relationship

Variations in terms of the effect size of instructional leadership across different cultural contexts were also identified in these reviews. Among studies of American schools, only a few have reported weak or small impacts of instructional leadership on student achievement (e.g., Hallinger et al. 1996; Alig-Mielcarek and Hoy 2005), while most have reported moderate effects (e.g., Heck 2000; Anderson 2008) and even large effects (Heck et al. 1990; Bamburg and Andrews 1991). For other countries, such as New Zealand, the Netherlands, and the Marshall Islands, the effects have been found to be weak or small (Krüger et al. 2007; Bruggencate et al. 2012). These findings show that the impact of instructional leadership on student academic achievement varies greatly across countries; it is much larger for the US than in other countries. In addition, the impact of instructional leadership on math is larger than that on reading (Alig-Mielcarek and Hoy 2005).

Different dimensions of instructional leadership

In addition to exploring the impact of overall instructional leadership, reviews have been conducted to determine how particular dimensions of instructional leadership affect student outcomes (Witziers et al. 2003; Robinson et al. 2008; Zheng et al. 2017). In a meta-analysis focusing on the direct effects of leadership on students' academic achievements, the importance of goal setting was suggested. Although the overall impact of leadership on students was negligible, goal setting was found to have a more direct impact on student outcomes than any of the other six dimensions (Witziers et al. 2003). In a meta-analysis review by Robinson et al. (2008), the impacts of five dimensions of instructional leadership on student achievement were examined. These authors found that promoting and participating in teacher learning and development has a large effect (ES = 0.84). Establishing goals and expectations has a moderately large and educationally significant indirect effect on students (ES = 0.42). Planning, coordinating, and evaluating teaching and the curriculum have a moderate impact on student outcomes (ES = 0.42). Strategic resourcing (principals' decisions about staffing and teaching resources with instructional purposes instead of skills in fundraising, grant writing, or partnering with businesses) has a small indirect impact on student outcomes (ES = 0.31). Ensuring an orderly and supportive environment also has a small indirect impact

on student outcomes (ES = 0.27). The authors conclude that the more principals focus on teaching and learning, the greater their influence on students' academic achievement. Similar findings were also uncovered in many other studies (Friedkin and Slater 1994; Marks and Printy 2003).

Rationale for the current study

The question of how principals' instructional leadership impacts students' academic achievement continues to attract scholars' attention worldwide. The effects vary greatly among different countries, different school types, and even different subjects. The impacts of different instructional leadership dimensions can also differ. In the current research, we focus on high schools in China. There are three main reasons for this focus. First, given the exclusion of high schools from compulsory education in China, enrolment in high schools is highly competitive. Furthermore, because students are selected into different high schools based on their academic performance, there is a wide gap in educational quality among different high schools. As a result, whether a strong school with a successful principal matters to students becomes a critical question. Second, in Chinese high schools, students are asked to choose to learn either liberal arts or science as their major when they enter 11th grade. Different choices determine the specific subjects high school students study in the last two years of high school and the majors they can choose when entering college. It remains unknown whether the impact of principals' instructional leadership on high school students' academic achievement varies between majors. Third, the college entrance examination, "Gaokao", a unique university admission system, not only creates pressure for students but also poses a major challenge for Chinese principals. It is necessary to explore the extent to which school principals' instructional leadership is helpful to both students and schools for this important test, which can determine students' future life.

Overall, it is necessary to explore whether principals' instructional leadership can explain the variation across schools and how principals' instructional leadership and its different dimensions influence students' academic achievement in the Chinese context. It is hypothesised that instructional leadership will significantly predict students' college entrance scores after controlling for students' background information, school context, and principals' demographic variables. It is also hypothesised that this effect is significant for both liberal arts students and science students.

Method

Participants and procedure

All 29 high schools in Shenyang, China, were invited to participate in the study. Shenyang, located in northeast China, is the capital and largest city of Liaoning Province. Shenyang is also an important industrial centre in northeast China, with a residential population of approximately 6.3 million. All the high school principals were asked to complete a survey that assessed their instructional leadership and collected their demographic information as well as basic information about their schools. The survey was administered after students participated in the college entrance test.

Approximately, 160 students were randomly selected from each school. Due to some missing values in the principals' demographics, the final sample contained 26 high schools with 26 principals and 4288 students, including 1738 male students and 2250 female students. For each student, both high school entrance scores and college entrance scores were collected through the local education administration office. Given that all the information is confidential, anonymity was maintained for all the students. The only identified demographic information was their gender and major in high school. As explained earlier, high school students need to select their major upon entering 11th grade (either a science major or a liberal arts major). In our sample, there were 2672 students (male = 1398, female = 1274) in the science major and 1316 liberal arts students (male = 340, female = 976). We differentiated between these two groups to determine whether principals' influences on students' majors differ in some way. All the high schools had both majors for students. However, more students choose science, which explains why the sample size for the science group is much larger than that of the liberal arts group.

Measures

Revised instructional leadership questionnaire of China

The ILQC-R, which was revised from the ILQC (Zhao and Liu 2010), was used in this study to assess Chinese principals' instructional leadership. The meaning of each dimension is shown in Table 2. The scale includes 50 items rated on a 5-point Likert scale ranging from (1) rarely occurs to (5) very frequently occurs. With the aim of validating the psychometric properties of the ILQC-R, another study was conducted. A total of 692 school staff from 40 schools were selected in Beijing, China. We conducted

Table 2 Meaning of each dimension of the ILQC-R

Dimensions	Number of items	Meaning
Defining school mission and goals	16	Principals lead the idea and methods in planning instruction content, target, and objective (promoting students development), and establishing high, concrete goals for the general functioning of the school, all curriculum, instruction, and assessment
Promoting teacher development	14	Principals provide guidance for teachers' career planning and ensure necessary resources and opportunities for teachers' professional development that directly enhance their teaching
Managing instruction	10	Principals monitor teaching and learning, and guide the instruction through class visitation, class evaluation, meetings, and communication with teachers and students
Managing public relations	10	Principals coordinate relations within and outside school, provide resources supporting teaching activities, and create instruction environment from the macro level to provide good conditions for teaching and learning

Table 3 The Cronbach's alpha reliability coefficients of the ILQC-R

	Total	Defining school mission and goals	Promoting teacher development	Managing instruction	Managing public relations
Number of items	50	16	14	10	10
Cronbach's alpha	0.981	0.966	0.951	0.950	0.948

Table 4 The CFA model fit index of the ILQC-R

Number of items	χ^2	df	χ^2/df	TLI	CFI	RMSEA
50	3883.264	1165	3.333	0.910	0.915	0.058

Table 5 The factor loadings of the ILQC-R

	Total	Defining school mission and goals	Promoting teacher development	Managing instruction	Managing public relations
Number of items	50	16	14	10	10
Factor loadings range	0.533 ~ 0.869	0.705 ~ 0.850	0.533 ~ 0.850	0.765 ~ 0.856	0.685 ~ 0.869

a confirmatory factor analysis and consistency reliability analysis. The Cronbach's alpha reliability coefficients for the entire questionnaire and for each of the four subscales were all above 0.90 (see Table 3), calculated in SPSS 18.0. The two-order confirmatory factor analysis of the questionnaire, in which the first order included 4 factors (i.e., 4 dimensions of the ILQC-R) and the second order included one factor (i.e., the overall instructional leadership), also indicated good model fit (see Table 4), with all the factor loadings ranging from 0.533 to 0.918 (see Tables 5 and 6); these were calculated in Mplus 7.11. In this study, the principals completed the ILQC-R. The item scores from each leadership dimension were averaged to create four-dimensional scores for each principal. An overall instructional leadership score was also calculated based on the overall average of the 50 items.

Table 6 The factor loadings of each dimension on the ILQC-R

	Defining school mission and goals	Promoting teacher development	Managing instruction	Managing public relations
Factor loadings	0.918***	0.834***	0.890***	0.882***

***$p < 0.001$

Student achievement variables

In the current study, students' high school entrance scores and college entrance scores (Gaokao) were collected. The former were used as a predictive variable, while the latter were used as a dependent variable. Both were measured by

large-scale standardised tests. Each student's high school entrance achievement is the sum score of the following subjects: Chinese, math, English, physical, chemistry, history, and politics. College entrance exams for liberal arts students cover Chinese, math, English, and liberal arts (including history, geography, and politics), while the exam for science students covers Chinese, math, English, and science (including physics, chemistry, and biology). Thus, the college entrance exam score for each student is the sum score of all the subjects that the student takes in his or her college entrance exam. Additionally, different majors in universities have different requirements for admission to liberal arts or science. For example, history, philosophy, and politics only admit liberal arts students; physics, chemistry, and computer science only admit science students; and education and psychology may admit both liberal arts and science students. Given that the students in liberal arts and science take different tests, we investigate the relationship separately for the two groups.

Student demographics, school context, and principal demographics

Students' gender and high school entrance scores were used as student-level control variables. Several control variables from each school were also collected, including being a provincial key high school. Principals' demographic variables included the principal's highest educational degree and years as a principal in the current school.

Variables

Dependent variables

The college entrance scores of liberal arts and science students were used as dependent variables.

Independent variables

The independent variables included student-level independent variables (gender, high school entrance scores) and school-level independent variables (school context, principals' demographics, and principals' instructional leadership). The specific description and coding method of the independent variables is given in Table 7.

Data analysis

Given that the data in the current study had a nested structure with students nested in schools, two-level HLM was employed to model the individual- and school-level variables to answer the research questions. HLM has been widely applied as an efficient method to predict dependent variables based on multiple independent variables from different levels and to examine the interactions across different levels (Raudenbush and Bryk 2002). The main reason is that HLM has advantages in dealing with the problems of traditional regression analysis, such as aggregation bias and underestimated standard errors (Lee 2000). The HLM process generally includes the following steps.

Table 7 Names and coding methods of independent variables

Independent variables	Explanation	Coding methods
Student-level independent variables		
Gender	Student gender	Categorical variable, 0 = male, 1 = female
High school entrance scores	Student high school entrance scores	Continuous variable, centred at student level, the higher the score the higher level of students' learning ability
School-level independent variables		
Being provincial key high school	Whether provincial key high school or not	Categorical variable, 0 = no, 1 = yes
Principal's highest degree	The highest degree of principal, representing the education level of the principal	Categorical variable, 0 = bachelor, 1 = master
The years of being principal in current school	The years of being principal in current school	Continuous variable, the higher the value, the longer being principal in current school
Instructional leadership	The general index of principal's instructional leadership, composed of 50 items	Continuous variable, centred at school level, the larger the score the more a person is perceived as being a instructional leader
Defining school mission and goals	One of the demotions of instructional leadership, composed of 17 items	Ditto
Promoting teacher development	Ditto, composed of 10 items	Ditto
Managing instruction	Ditto, composed of 18 items	Ditto
Managing public relations	Ditto, composed of 6 items	Ditto

First, the analysis begins with a null model, which is performed to determine the existence and degree of within- and between-school variance in the total variation. All the Intra Class Coefficients (ICCs) were above 50%, which justified the need to conduct HLM (see Table 8). Null model:

Student level: school j, student i

$$Y_{ij} = \beta_{0j} + r_{ij}, \quad r_{ij} \sim N(0, \sigma^2)$$

School level: school j

$$\beta_{0j} = \gamma_{00} + u_{0j}, \quad u_{0j} \sim N(0, \tau_{00})$$

Y_{ij} represents student college entrance scores (for liberal arts students and science students); γ_{00} represents the grand mean of student college entrance scores; and r_{ij} and μ_{0j} represent student-level residuals and school-level residuals, respectively.

Model 2 was developed to determine the degree of between-school variance when students' high school entrance scores and students' gender were controlled. In Model 3, school-level independent variables, with the exception of instructional leadership, were added to (1) predict the average of students' academic achievement (the intercept) and (2) predict the slope indicating the relationship between the high school entrance score and college entrance score. The final model was based on Model 3, in which instructional leadership and its four dimensions were added to predict both the intercept of outcomes and the slope. The final model is as follows:

Student level: school j, student i

$$\begin{aligned} Y_{ij} = {} & \beta_{0j} + \beta_{1j}(\text{high school entrance score})_{ij} \\ & + \beta_{2j}(\text{gender})_{ij} + r_{ij}, \quad r_{ij} \sim N(0, \sigma^2) \end{aligned}$$

School level: school j

$$\begin{aligned} \beta_{0j} = {} & \gamma_{00} + \gamma_{01}(\text{being a provincial key high school})_j \\ & + \gamma_{02}(\text{principal's highest degree})_j \\ & + \gamma_{03}(\text{years of being provincial in current school})_j \\ & + \gamma_{04}(\text{instructional leadership})_j + u_{0j}, u_{0j} \sim N(0, \tau_{00}) \end{aligned}$$

$$\begin{aligned} \beta_{1j} = {} & \gamma_{10} + \gamma_{11}(\text{being provincial key high school})_j \\ & + \gamma_{12}(\text{principal's highest degree})_j \\ & + \gamma_{13}(\text{years as principal in current school})_j \\ & + \gamma_{14}(\text{instructional leadership})_j + u_{1j}, u_{1j} \sim N(0, \tau_{11}) \end{aligned}$$

$$\beta_{2j} = \gamma_{20} + u_{2j}, u_{2j} \sim N(0, \tau_{22})$$

Y_{ij} represents students' college entrance scores (for liberal arts students and science students). γ_{00} represents the grand mean of students' college entrance scores. γ_{10} andγ_{20} represent the mean slope of high school entrance scores and the mean slope of gender at the school level, respectively. $\gamma_{01} - \gamma_{03}$ represent the direct effects of being a provincial key high school, the principal's highest educational degree, and the principal's years employed as the principal in the current school on students' college entrance scores, respectively. $\gamma_{11} - \gamma_{13}$ represent the moderating effects of being a provincial key high school, the principal's highest educational degree, and the principal's years employed as the principal in the current school on the relationship between high school entrance scores and college entrance scores, respectively. γ_{04} represents the direct effect of overall instructional leadership or its dimensions on students' college entrance scores. γ_{14} represents the moderating effect of overall instructional leadership or its dimensions on the relationship between high school entrance scores and college entrance scores. r_{ij} represents student-level residuals, μ_{0j} represents school-level residuals from the intercept, and μ_{1j} and μ_{2j} represent school-level residuals from the slope indicating the relationship between high school entrance scores and college entrance scores and the slope indicating the relationship between gender and college entrance scores, respectively.

Table 8 The ICC of college entrance scores (26 schools)

	Liberal arts students	Sciences students
Intercept	458.678***	426.484***
Residual (student)	2408.206***	2974.551***
Residual (school)	4443.467***	6557.017***
ICC (school)	0.649	0.688

***$p < 0.001$

Results

Finding 1: students' gender and high school entrance scores showed a significant influence on students' college entrance scores

According to Model 2, in both the liberal arts and science groups, students' scores on the high school entrance exams showed a significantly positive and consistent influence on students' scores in the college entrance exams, with a higher level of high school entrance scores leading to a higher level of college entrance scores. However, it was found that the influences of gender differed dramatically in the two groups. Female students studying liberal arts tended to outperform their male peers. In contrast, in science, male students tended to achieve higher performance than female students. Although only two variables were included, more than 20% of the variance in college entrance scores within schools was reduced, and the reduced variance in college entrance scores between schools was very large (93.63% for liberal arts students and 96.51% for science students). This finding indicates

that the variances in the college entrance scores between schools are mainly caused by high school entrance scores, especially for science students.

Finding 2: school context and principals' demographics showed significant influences on students' college entrance scores

Model 3 indicates that school-level control variables showed a significant influence in predicting the school's average college entrance scores (the intercept) of both liberal arts students and science students. Significant interaction effects between school-level control variables and students' high school entrance scores were also found.

For the liberal arts group (see Table 9), the principal's highest degree ($\gamma_{02} = 9.322$, $p > 0.05$) and years employed as the principal in the current school ($\gamma_{03} = -0.965$, $p > 0.05$) did not have a significant impact on the outcome variable. In contrast, "being a provincial key high school" was a significant factor that positively predicted the school's average college entrance scores ($\gamma_{01} = 21.041$, $p < 0.05$). More specifically, for the "provincial key high schools", the average college entrance score for liberal arts students was 21.041 points higher than that of normal schools. Moreover, the

Table 9 The results of models for liberal arts student college entrance scores (26 schools)

Variable	Parameter	Model 2	Model 3	Model 4_Vt	Model 4_V1	Model 4_V2	Model 4_V3	Model 4_V4
Fixed effect								
Student level								
The intercept of the college entrance scores	γ_{00}	431.244***	422.279***	421.578***	420.950***	422.373***	420.113***	421.355***
High school entrance score	γ_{10}	0.943***	0.489***	0.531***	0.532***	0.534***	0.544***	0.490***
Gender	γ_{20}	9.715***	10.060***	9.872***	9.868***	10.057***	9.952***	10.026***
School level								
Intercept								
Being provincial key high school	γ_{01}		21.041*	22.112*	21.767*	21.430*	23.168*	23.902*
Principal's highest degree	γ_{02}		9.322	10.188	10.366	9.734	11.087	10.626
The years of being principal in current school	γ_{03}		−0.965	−0.819	−0.619	−1.004	−0.690	−1.149
Instructional leadership	γ_{04}			0.690	2.538	4.190	−2.137	−10.422
Slope of high school entrance score								
Being provincial key high school	γ_{11}		0.377**	0.308*	0.301*	0.322*	0.304*	0.367*
Principal's highest degree	γ_{12}		−0.091	−0.158	−0.164	−0.147	−0.165	−0.095
The years of being principal in current school	γ_{13}		0.064**	0.065**	0.065**	0.062**	0.062**	0.064**
Instructional leadership	γ_{14}			0.266**	0.281*	0.218*	0.280***	0.049
Random effects								
Student level	σ^2	1740.375***	1737.819***	1737.828***	1738.992***	1736.542***	1738.706***	1738.053***
School level	τ_{00}	282.974*	219.461***	225.234***	226.767***	225.194***	220.753***	205.814**
	τ_{11}	0.098***	0.040*	0.032	0.028	0.035	0.028	0.039*

Model 4_Vt expressed that in the fourth model, the variable Instructional leadership was total principal instructional leadership. Accordingly, Model 4_V1 ~ Model 4_V4 that were said in the fourth model, instructional leadership were, respectively, the four sub-dimensions, (V1) defining school mission and goals, (V2) promoting teacher development, (V3) managing instruction, and (V4) managing public relations. The same below

*Variable is significant at the 0.05 level

**Variable is significant at the 0.01 level

***Variable is significant at the 0.001 level

relationship between students' high school entrance scores and their college entrance scores was found to be positively moderated by "being a provincial key high school" ($\gamma_{11}=0.377$, $p<0.05$), indicating that for students enrolled in a "provincial key high school", the influence of high school entrance scores on their college entrance scores is much stronger than that of students in a normal high school. Such moderation effects were also observed for the variable of "years employed as principal in the current school" ($\gamma_{13}=0.064$, $p<0.01$). The percentage of variance between schools explained by the variables in the model was 95.06% (as compared to Model 1; see Table 10).

For the science major group (see Table 11), "being a provincial key high school" was also observed to have a significantly positive influence on both the intercept ($\gamma_{01}=28.496$, $p<0.001$) and slope ($\gamma_{11}=1.238$, $p<0.001$), which is consistent with the finding for the liberal arts students. More specifically, if a school is evaluated as a "provincial key high school", not only is the school's average college entrance score for science students 28.496 points higher, but the impact of science students' high school entrance scores on their college entrance scores is also stronger than for those schools that are not regarded as "provincial key high schools". Moreover, "principal's highest educational degree" ($\gamma_{02}=12.091$, $p<0.01$) and "years employed as principal in the current school" ($\gamma_{03}=3.520$, $p<0.001$) showed significant and positive effects on the school's average college entrance score. If a school principal's highest educational degree is a master's degree, his/her school's average college entrance score for science students is 12.091 points higher than for those schools whose principals only have bachelor's degrees. Additionally, every additional year employed as the principal in the current school leads to a 3.52-point increase in the school's average college entrance score. However, neither of these two predictors showed a significant influence on the relationship between students' high school entrance scores and college entrance scores ($\gamma_{12}=0.197$, $p>0.05$; $\gamma_{13}=0.026$, $p>0.05$). The overall percentage of variance between schools explained by the variables in the model was 99.24% (as compared to Model 1; see Table 12).

Finding 3: significant impacts of instructional leadership on the relationship between high school entrance scores and college entrance scores were found

It was discovered in Model 4 (see Tables 9, 11) that instructional leadership had dissimilar influences on students' college entrance scores in the two groups. For liberal arts students, none of the principal's instructional leadership or its various dimensions directly and significantly predicted the school's average college entrance scores ($p>0.05$), but higher levels of instructional leadership ($\gamma_{14}=0.266$, $p<0.01$) and higher levels of three of its four dimensions, defining the school mission and goals ($\gamma_{14}=0.281$, $p<0.05$), promoting teachers' development ($\gamma_{14}=0.218$, $p<0.05$), and managing instruction ($\gamma_{14}=0.280$, $p<0.001$), led to a significantly strong impact on the relationship between high school entrance scores and college entrance scores. Taking the dimension of defining the school mission and goals as an example, with each additional unit of defining the school mission and goals, the strength of the relationship between students' high school entrance scores and college entrance scores increased by 0.281 units. In other words, a school principal's greater competence in defining the school mission and goals is related to students' more rapid growth in achievement. However, this significant moderating effect was not observed for the dimension of managing public relations ($\gamma_{14}=0.049$, $p>0.05$) (see Table 9). The percentage of variance between schools explained by the variables in the model varied from 94.90 to 95.37%, respectively (as compared to Model 1), similar to Model 3 (see Table 10).

For science students, only managing instruction ($\gamma_{04}=14.424$, $p<0.05$) showed a significant direct effect on the school's average college entrance scores; in contrast, principals' instructional leadership and its other three dimensions did not significantly predict the school's average college entrance scores ($p>0.05$). This result indicates that with each additional unit of managing instruction, the school's average college entrance scores increase by 14.424 points. In addition, principals' instructional leadership

Table 10 Comparison of random effects of different models of liberal arts students (26 schools)

	Model 1	Model 2	Model 3	Model 4_Vt	Model 4_V1	Model 4_V2	Model 4_V3	Model 4_V4
Student level								
Random effects	2408.206	1740.375	1737.819	1737.828	1738.992	1736.542	1738.706	1738.053
Reduced random effects	–	667.831	670.387	670.378	669.214	671.664	669.500	670.153
Explanation ratio	–	27.73%	27.84%	27.84%	27.79%	27.89%	27.80%	27.83%
School level								
Random effects	4443.467	283.072	219.501	225.266	226.795	225.229	220.781	205.853
Reduced random effects	–	4160.395	4223.966	4218.201	4216.672	4218.238	4222.686	4237.614
Explanation ratio	–	93.63%	95.06%	94.93%	94.90%	94.93%	95.03%	95.37%

Table 11 The results of models for science student college entrance scores (26 schools)

Variable	Parameter	Model 2	Model 3	Model 4_Vt	Model 4_V1	Model 4_V2	Model 4_V3	Model 4_V4
Fixed effect								
Student level								
The intercept of the college entrance scores	γ_{00}	450.510***	410.902***	413.415***	412.477***	412.715***	412.285***	410.820***
High school entrance score	γ_{10}	1.694***	0.863***	0.947***	0.945***	0.914***	0.937***	0.872***
Gender	γ_{20}	−7.845***	−8.162***	−8.146***	−8.115***	−8.166***	−8.169***	−8.165***
School level								
Intercept								
Being provincial key high school	γ_{01}		28.496***	26.128***	25.853***	27.616***	27.252***	28.655***
Principal's highest degree	γ_{02}		12.091**	9.263*	9.807*	10.790*	10.048**	11.852*
The years of being principal in current school	γ_{03}		3.520***	3.605***	3.825***	3.360***	3.671***	3.529***
Instructional leadership	γ_{04}			14.933	15.311	6.793	14.424*	0.004
Slope of high school entrance score								
Being provincial key high school	γ_{11}		1.238***	1.169***	1.146***	1.212***	1.173***	1.226***
Principal's highest degree	γ_{12}		0.197	0.111	0.116	0.155	0.119	0.183
The years of being principal in current school	γ_{13}		0.026	0.024	0.026	0.022	0.024	0.027
Instructional leadership	γ_{14}			0.321*	0.341**	0.139	0.298*	0.068
Random effects								
Student level	σ^2	2333.243***	2333.631***	2331.920***	2331.658***	2332.208***	2332.910***	2333.554***
School level	τ_{00}	228.591*	49.674	55.904	55.844	55.271	48.922	50.448
	τ_{11}	0.326**	0.032*	0.024	0.022	0.030	0.019	0.031

*Variable is significant at the 0.05 level

**Variable is significant at the 0.01 level

***Variable is significant at the 0.001 level

Table 12 Comparison of random effects of different models of science students (26 schools)

	Model 1	Model 2	Model 3	Model 4_Vt	Model 4_V1	Model 4_V2	Model 4_V3	Model 4_V4
Student level								
Random effects	2974.551	2333.243	2333.631	2331.92	2331.658	2332.208	2332.91	2333.554
Reduced random effects	–	641.308	640.92	642.631	642.893	642.343	641.641	640.997
Explanation ratio	–	21.56%	21.55%	21.60%	21.61%	21.59%	21.57%	21.55%
School level								
Random effects	6557.017	228.917	49.706	55.928	55.866	55.301	48.941	50.479
Reduced random effects	–	6328.1	6507.311	6501.089	6501.151	6501.716	6508.076	6506.538
Explanation ratio	–	96.51%	99.24%	99.15%	99.15%	99.16%	99.25%	99.23%

($\gamma_{14} = 0.321$, $p < 0.05$) and two of its dimensions, defining the school mission and goals ($\gamma_{14} = 0.341$, $p < 0.001$) and managing instruction ($\gamma_{14} = 0.298$, $p < 0.05$), can significantly enhance the impact of high school entrance scores on college entrance scores, while the other two dimensions, promoting teacher development ($\gamma_{14} = 0.139$, $p > 0.05$) and managing public relations ($\gamma_{14} = 0.068$, $p > 0.05$), do not show such a significant influence (see Table 11). The percentage of variance between schools explained by the variables in the model varied from 99.15 to 99.25% (as compared to Model 1), similar to Model 3 (see Table 12).

Discussion

After the emergence of the concept of instructional leadership, considerable evidence has supported the idea that instructional leadership can have positive impacts on students' achievements. However, the empirical evidence in China is scarce. The most important contribution of this research was to add to the handful of existing studies by examining the influences of instructional leadership in the Chinese context. In China, high school education is not part of the compulsory education system. Unlike their counterparts in Western countries, such as the United States, where high school education has been integrated into the compulsory education system, Chinese students are selected into high school based on their performance on a very competitive exam, the high school entrance exam. The entire selection system is managed and organised by the local county education government. Students are ranked by their high school entrance scores and then placed into high schools with different levels. In this way, students with better scores are enrolled in better high schools, and students with lower scores are enrolled in lower-quality high schools. Therefore, it is unsurprising that there has been a long-standing concern and debate about whether school principals affect students' academic performance. The empirical evidence obtained in this study provides important implications about the roles of high school principals. Furthermore, both students' high school entrance scores and college entrance scores were included in the model with the aim of using the former as the predicting variable. Thus, we can identify how instructional leadership moderates the relationship between these two variables. This research also sheds light on the potential influence of instructional leadership over time.

The impact of instructional leadership on high school students' academic achievement

This study investigated the impact of principals' instructional leadership and four dimensions of instructional leadership on students' college entrance scores while controlling the student-level and school-level variables. The most important and interesting finding was that principals' overall instructional leadership does not dramatically influence the school's final average college entrance scores; rather, principals' overall instructional leadership significantly moderates the relationship between high school entrance scores and college entrance scores for students in both the liberal arts and science, even though the influential demographic variables were controlled in the model. In other words, instructional leadership can influence the growth rate of achievement in high schools. More competitive instructional leadership facilitates students' achievement growth. The results of this study are consistent with previous results in some ways. Many studies have indicated that there is a significantly positive relationship between instructional leadership and students' academic achievement. As a result, researchers have proposed that improving instructional leadership might improve students' academic achievement (Brewer 1993; Heck 2000; Robinson et al. 2008).

In addition to general overall instructional leadership, important implications were identified in terms of the different dimensions of instructional leadership on students' academic achievement, which align with the findings from another study that used the method of separate regression analyses (Shatzer et al. 2014). First, it is suggested that defining the school mission and goals has a key role in influencing high school students, specifically with regard to the growth rate of their achievement over their 3 years in high school. This result is not surprising since a direct effect of goal setting has been suggested based on the findings from the meta-analysis conducted by Witziers et al. (2003). Many previous studies have found that leadership indirectly affects students through the degree of emphasis on clear academic and learning goals (Bamburg and Andrews 1991; Brewer 1993; Robinson et al. 2008). Therefore, our study suggests that school leaders need to establish clearly defined missions, goals, and expectations for the improvement and development of their schools, teachers, curriculums, and students. Such efforts to build stronger school missions could establish connections between educational reforms and teaching implementation, thus enabling teachers and students to better understand their teaching and learning behaviours. Moreover, a positive campus culture could be formed, and the motivation for students' learning and teachers' teaching could be enhanced. Finally, clear school missions and goals help principals, other school leaders, and teachers use feedback efficiently to monitor students' progress (Latham and Locke 2006; Robinson et al. 2008).

Second, the model showed that the dimension of promoting teachers' development had a significant moderating effect on the relationship between high school and college entrance scores for liberal arts students. This result is also consistent with previous findings. For example, Robinson et al. (2008)

provided sufficient empirical evidence to support a large effect of promoting teachers' learning and development on student outcomes and proposed that school leaders should actively take the role of "leading learners" in their schools. When student background factors are controlled, the more that teachers reported that their principals were active participants in teacher learning and development, the higher the students' scores were on the test (Andrews and Soder 1987; Bamburg and Andrews 1991). However, surprisingly, this positive relationship was not observed for science major students. This result indicates that a school principal's actions regarding teacher development have different effects on different students. In terms of a stronger finding for the promotion of teacher development for liberal arts students, this finding may also reflect a context in which the general teacher professional development programme meets the needs of liberal arts teachers better than the needs of science teachers.

The third dimension explored in this study was managing instruction, which included planning, coordinating, and evaluating teaching and the curriculum. In the current study, this dimension was revealed to be an influential factor on students' achievement growth. Robinson et al. (2008) noted that this dimension lies at the heart of instructional leadership and found a moderate impact of this dimension on students' outcomes. Principals in higher-performing schools are more involved in direct instructional leadership practices than those in similar lower-performing schools. In the context of China, competition among high schools is very intense, with the result that all high school principals highly emphasise teachers' instruction. The evidence based on the current study also reflects the reality in China that high school principals who possess greater capabilities in promoting instructional quality have a significantly positive influence on students' academic achievement.

The last dimension in the current study refers to principals' coordinating abilities within and outside the school, such as providing resource support for teaching activities. This dimension is called managing public relations and can be viewed as a combination of strategic resourcing and ensuring an orderly and supportive environment, as found in other studies (Zhao and Liu 2010; Zhao 2018). This dimension had no significant effects on high school students' academic achievement in the current study. This result is counter to the argument proposed by other scholars (Heck et al. 1991; Heck 2000; Zhao and Liu 2010). Heck et al. (1991) found that there was a small relationship between leaders' ability to secure instructional resources and student achievement in California schools and a large relationship in Marshall Island schools. Similarly, Heck (2000) found that the more positive the reactions were regarding the extent to which teachers, parents, and students felt safe, comfortable, and cared for, the higher the school quality and the higher its achievement levels were when student background factors were controlled. The inconsistent findings might be caused by the fact that in the Chinese context, the majority of high schools are public schools; in other words, they are funded by the government. All school resources are allocated by the government. Therefore, the investment is similar among different schools within a city. School principals do not have much autonomy in requesting different resource supports (Zhao 2018). On the other hand, many high schools in foreign countries are private, and the principals there play an important role in resource acquisition and the establishment of the campus environment. In addition, this study considered only the direct effects (including the moderating effects) of instructional leadership. As suggested by Robinson et al. (2008), both strategic resourcing and ensuring an orderly and supportive environment had small indirect impacts on student outcomes. Thus, the issue of whether Chinese high school principals' role in managing public relations has an indirect effect on their students' academic achievement deserves more exploration in the future.

The impact of school-level variables on high school students' academic achievement

Narrowing the academic quality gap between schools is an important way to improve both the quality and equity of education. In the current study, significant differences in college entrance scores among Chinese high schools were found for liberal arts and science students. The findings indicate that the school context and principals' demographics could explain some variance in college entrance scores between schools. However, the influence of these factors was quite complex and not consistent between the liberal arts group and the science group. Among all three factors, "being a provincial key high school" demonstrated consistent results for both liberal arts students and science students, including significant direct impacts on the school's average college entrance scores and a moderating influence on the relationship between high school entrance scores and college entrance scores. However, such a trend was not found for the other two factors. The dramatic influence of "being a provincial key high school" on student achievement is primarily due to the selection rules for high school students, as explained in the previous section. The influence indicates that excellent students with higher achievement are highly motivated and have better opportunities in typical elite schools, where the learning environment is very competitive.

The impact of students' high school entrance scores and students' gender on high school students' academic achievement

Students' high school entrance scores and gender were the only two student-level controlled variables in the current

study. When these factors were combined, the explanation ratio for random effects was over 20% at the student level and over 90% at the school level. The strong predictive value of gender on college entrance scores for both liberal arts students and science students provides evidence for the idea of a gender gap. The predictive value of gender indicates that the impacts of gender on high school students' academic achievement were opposite for liberal arts students and science students. Male students were better at science, while female students were better at liberal arts. These findings are aligned with previous studies. For example, PISA test results have consistently indicated that boys outperform girls in math and science, but girls perform better in reading.

In addition, the study revealed that students' previous achievement had the strongest influence on students' performance in college entrance exams for both liberal arts and science students. It is not surprising that high school entrance scores can predict college entrance scores to a large extent. This finding indicates two important issues. First, college entrance performance relies strongly on students' previous performance. Second, students' achievement growth should be considered an important criterion when assessing high schools' effectiveness; otherwise, the assessment is unfair for those high schools that can only recruit students with low academic achievement at the beginning of high school education.

Conclusion

Recent findings have indicated that a crucial step for schools to improve and sustain effectiveness in the long run is the principal's diagnosis of the school's needs and the principal's educational values combined with the application of diverse strategies (Day et al. 2016). Thus, while previous models have found evidence for direct or indirect effects of the principal's leadership in other cultural contexts, we conclude that principals' instructional leadership has an important positive influence on Chinese high school students' academic achievement. Our findings regarding the relative impact of the four instructional dimensions provide more detailed guidance for Chinese high schools about the behaviours of instructional leadership that make a difference for students' academic achievement. As other researchers have suggested, different leadership emphases are needed for schools at different stages of development (Robinson et al. 2008). For some schools, a focus on managing public relations may be an essential prior stage before principals can give more attention to the curriculum. However, a principal's instructional leadership is likely to have more positive impacts on high school students' academic achievement when the principal is able to focus on the quality of learning, teaching, and teacher development.

While the findings of this study highlight the importance of instructional leadership, they also provide some implications for future research. In the current Chinese education context, the contradiction between the existence of "Gaokao" and advocacy for "quality education" puts dual expectations on school leaders. Given the potential benefits of instructional leadership, it is important to understand how those principals who have demonstrated successful instructional leadership learned to do so. It is also critical to identify efficient strategies to train other school leaders so they can adapt leadership practices in different contexts. Moreover, it is necessary to design effective professional development programmes for school leaders and to continuously cultivate their instructional leadership in real situations (Qian et al. 2017).

Like all research, the current study has limitations. For example, this study only used students' academic achievement in the analysis model without considering non-academic achievement. Given that students' non-cognitive performance plays important roles in their future life, principals' capability to provide a positive environment for different aspects of students' development becomes increasingly important. Therefore, it is necessary to investigate how instructional leadership influences students' performance in both academic and non-academic contexts. Second, the HLM used to illustrate our quantitative conclusions was based on the responses of only principals, not their staff. The main criticism of the self-report method is the possibility of a social desirability bias (Su and Reeve 2011). Third, given that students' academic performance was measured only twice, we could not investigate the achievement change trajectory or the way instructional leadership might influence that trend. Finally, although some important confounding variables were considered in the model, others that were not included might show potential effects on the outcome variables. In future studies, teachers and other stakeholders could be included as respondents to investigate their principals' instructional leadership in addition to reports from the principals themselves. The results of this paper provide important implications for the public to understand the relationship between principals' instructional leadership and high school students' academic achievement in the Chinese context. However, caution needs to be taken when generalising these findings to other countries.

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